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## 316

The distance between the heels of a man's feet is  $2b$ , and the length of each foot is  $a$ . As the body sways, the vertical through the centre of gravity must always pass through the area contained by the feet. The toes should therefore be turned out at such an angle that the area contained by the feet is a maximum. Show (1) that a circle can be described about the feet with its centre on the straight line joining the toes, and (2) that the diameter of the circle is  $b + (2a^2 + b^2)^{\frac{1}{2}}$ . [E. J. Routh.]

SOLUTION.

Let  $\pi - \theta$  be the angle between the feet. The area contained is

$$\Omega = 2ab \sin \theta + \frac{1}{2}a^2 \sin 2\theta.$$

The condition for maximum is

$$d\Omega/d\theta = 2ab \cos \theta + a^2 \cos 2\theta = 0,$$

or

$$a \sec \theta = 2b + 2a \cos \theta.$$

Therefore the diagonal of the trapezoid is perpendicular to the sloped side and (1) is true. The diameter of the circle is

$$d = 2b + 2a \cos \theta.$$

Eliminating  $\theta$ ,

$$d = b + \sqrt{(2a^2 + b^2)}. \quad [W. H. Echols.]$$

## EXERCISES.

## 321

A CIRCLE meets a hypocycloid of class 3 at six finite points. Show that the tangents to the hypocycloid at these six points touch a conic.

[Frank Morley.]

## 322 \*

THE arc of a limaçon is shown in works on the Calculus to be equivalent to the arc of a certain ellipse. Show that the double point on the limaçon corresponds with Fagnani's point on the ellipse. [W. B. Richards.]

## 323

ONE of two casks contains  $a$  gallons of wine, and the other  $b$  gallons of water;  $c$  gallons are taken from the first and poured into the second cask, and then  $c$  gallons are taken from the second and poured into the first. Required the quantity of wine in the second cask after  $n$  such operations.

[Artemas Martin.]

## 324

A SUCTION pump is connected with a reservoir by a pipe of the same diameter as the piston. How many strokes are needed to bring water?

[*W. H. Echols.*]

## 325

DISCUSS the case of two forces acting together upon a particle, one force being directed to the centre, and the other directed to one focus of an ellipse, under the influence of which forces the particle freely describes the ellipse.

[*Yale Prize Problem.*]

## 326

A HORIZONTAL beam, span  $2a$ , is supported at each end; the load per running foot of length at one support is zero; at the other support  $b$ . Find the deflection of the beam at the centre due to this load,

(1) When the load increases from zero-support to  $b$ -support as the square of the distance;

(2) When the load increases as the square root of that distance.

[*T. U. Taylor.*]

## 327

FIND an approximate value for the perturbation of a comet by the sun, when the comet is very near a planet. (See Watson's *Astronomy*, p. 550.)

[*A. Hall.*]

## 328

A BUBBLE of air is released below the surface of a still pond; discuss its form and motion.

[*W. H. Echols.*]

## LUDLOW'S TRIGONOMETRY.\*

The author of this treatise does not write for mathematicians, but only for those who intend solving triangles, and for their convenience has added trigonometric and logarithmic tables. Regarded in that light, the work is fairly good, but rather lengthy and in some parts inexplicit.

It may be remarked, moreover, that the day has long since departed when students were taught that the sine of an *angle* was the function of the *corresponding arc*. A comparison between this work and those that its author consulted in preparing his own, shows that most of them are to be preferred to the new. Chauvenet, for instance, gives in 16 pages that for which Ludlow requires 39, and in a style considerably to be preferred. Another author gives the same matter (*Trigonometric Functions of an Angle*) in 12 pages, and in a clearer style than either of them.

C. L. D.

\* TRIGONOMETRY. By Henry H. Ludlow. 294 pp. 8vo. John Wiley & Sons, New York. 1891.